

CLAIMS

- 5 1. An interface device for interfacing a user's input with a host computer and providing force feedback to said user, said interface device comprising:
- a user manipulandum contacted and manipulated by a user and moveable in a planar workspace with respect to a ground surface;
- a manipulandum sensor coupled to said user manipulandum for detecting a position of said user manipulandum in said planar workspace and operative to send a position signal to said host computer indicating a position of said user manipulandum in said workspace;
- a rotatable wheel coupled to said user manipulandum and rotatable about a wheel axis;
- a wheel sensor coupled to said wheel and providing a wheel signal to said host computer indicating a rotary position of said wheel;
- a wheel actuator coupled to said rotatable wheel and operative to apply a computer-modulated force to said rotatable wheel about said wheel axis, wherein said force is modulated as a function of time or wheel position about said wheel axis.
- 10 2. An interface device as recited in claim 1 wherein said user manipulandum includes a mouse object.
- 20 3. An interface device as recited in claim 2 wherein said manipulandum sensor includes a ball and roller assembly.
4. An interface device as recited in claim 2 further comprising an actuator for applying a force to said user manipulandum in said workspace.
5. An interface device as recited in claim 4 wherein said actuator is coupled to said user manipulandum by a mechanical linkage having a plurality of members.
- 25 6. An interface device as recited in claim 2 wherein said rotary wheel rotates about an axis parallel to said planar workspace.
7. An interface device as recited in claim 2 wherein said wheel actuator is coupled to said wheel by a belt drive mechanism.

8. An interface device as recited in claim 2 wherein said wheel actuator is directly coupled to said wheel.

9. An interface device as recited in claim 2 wherein said wheel can be depressed into a housing of said user manipulandum.

5 10. An interface device as recited in claim 2 wherein said wheel is coupled to a first shaft that is coupled to and rotatable about a second shaft, said second shaft being coupled to said wheel actuator.

0 11. An interface device as recited in claim 1 further comprising a local microprocessor, separate from host computer, coupled to said actuator and controlling said actuator to apply said computer-modulated force on said wheel.

5 12. An interface device as recited in claim 1 wherein said host computer is running a graphical environment and wherein said force applied to said wheel corresponds with an event or interaction displayed in said graphical environment.

10 13. An interface device as recited in claim 1 wherein said wheel actuator outputs a set of isotonic forces when said interface device is in an isotonic mode, and wherein said wheel actuator outputs a set of isometric forces when said interface device is in an isometric mode.

15 14. An interface device as recited in claim 1 further comprising a safety switch coupled to said wheel, said safety switch operative to disable said application of said force when said user is not contacting said wheel.

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15. A handheld force feedback remote control device for providing input to an electronic device located remotely from said remote control device, the remote control device comprising:

a wheel rotatably coupled to a housing of said remote control device and rotatable about an axis, said wheel being manipulated by a user;

25 an actuator coupled to said wheel for outputting a computer-modulated force detent on said wheel, said force detent felt by said user, wherein said force detent is provided at a predetermined rotational position of said wheel; and

a sensor that senses rotation of said wheel and provides a wheel signal to said electronic device indicating a rotary position of said wheel.

16. A force feedback wheel device as recited in claim 15 wherein said force detent includes an attractive force for biasing said wheel to said predetermined rotational position

5 *Sub A* 17. A force feedback wheel device as recited in claim 15 wherein said remote control device sends signals to said electronic device using wireless transmission of information using an electromagnetic beam.

Sub Aq 18. A force feedback wheel device as recited in claim 15 wherein said electronic device includes a video game console and wherein said remote control device includes a game controller for inputting signals to said video game console.

19. A force feedback wheel device as recited in claim 15 wherein additional forces can be applied to said wheel, said additional forces including at least one of a damping force sensation, an inertial force sensation, a friction force sensation, a spring force sensation, a force detent sensation, an obstruction force sensation, a texture sensation, a jolt sensation, and a vibration sensation.

20. A force feedback wheel device for providing input to an electronic radio, the wheel device comprising:

a wheel rotatably coupled to a housing of said electronic radio and rotatable about an axis, said wheel being manipulated by a user;

20 an actuator coupled to said wheel for outputting a computer-modulated force detent on said wheel, said force detent felt by said user, wherein said force detent is provided at a predetermined user-preferred rotational position of said wheel; and

a sensor that senses rotation of said wheel and provides a wheel signal to said electronic device indicating a rotary position of said wheel;

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21. A force feedback wheel device as recited in claim 20 wherein said force detent includes an attractive force for biasing said wheel to said predetermined rotational position

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22. A force feedback wheel device as recited in claim 20 wherein said predetermined user-preferred positions are positions of preferred radio station frequencies in a radio frequency range.

23. A force feedback wheel device as recited in claim 20 wherein additional forces can
5 be applied to said wheel, said additional forces including at least one of a damping force
sensation, a spring force sensation, an inertial force sensation, a friction force sensation, a force
detent sensation, an obstruction force sensation, a texture sensation, a jolt sensation, and a
vibration sensation.

24. A method for providing a force feedback mouse wheel on a mouse interface device, said mouse interface device coupled to a host computer, the method comprising:

sensing a position of a mouse of said mouse interface device in a planar workspace and sending an indication of said position to a host computer;

sensing a rotation of said mouse wheel about an axis of rotation and sending a wheel signal to said host computer indicating a current position of said wheel about said axis; and

applying a force to said mouse wheel about said axis using a wheel actuator coupled to said mouse wheel, wherein said force is coordinated with an event occurring in said graphical environment.

- 20 25. A method as recited in claim 24 wherein said sensing a rotation of said mouse wheel
includes sensing an absolute position of said mouse wheel about said axis.

26. A method as recited in claim 24 wherein said sensing a rotation of said mouse wheel includes sensing a change in position of said mouse wheel from a previously sensed position.

27. A method as recited in claim 24 wherein said applying a force to said mouse wheel is commanded by a local microprocessor included in said mouse interface device and separate from said host computer.

28. A method as recited in claim 24 wherein said event is a scrolling of a displayed document as controlled by said sensed rotation of said mouse wheel and said wheel signal.

29. A method as recited in claim 24 wherein said event is an interaction of a cursor with a graphical object implemented by said host computer, said cursor having motion influenced by said rotation of said wheel.

30. A method as recited in claim 29 wherein said interaction is a collision of said cursor
5 with said graphical object.

31. A method as recited in claim 24 wherein said force is one of a damping force sensation, an inertial force sensation, and a friction force sensation.

32. A method as recited in claim 24 wherein said force is a force detent sensation.

33. A method as recited in claim 24 wherein said force is one of an obstruction force sensation, a texture sensation, a jolt sensation, and a vibration sensation.

34. A method as recited in claim 24 further comprising applying a force to said mouse object in said planar workspace using an actuator different from said wheel actuator.

35. A method as recited in claim 24 further comprising receiving a mode selection, said mode selection indicating an isotonic mode or an isometric mode for said mouse wheel, wherein said force applied to said mouse wheel are different depending on said selected mode.

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